Workshop

Modelling and Numerics of Conservation Laws

February 16, 2011

Institut für Mathematik 2-413, Staudinger Weg 9, Room 05-432

13:00 - 13:50

Prof. Dr. Miloslav Feistauer, DrSc. (Charles University, Prag)

Discontinuous Galerkin Method for the Numerical Simulation of Interaction of Compressible Flow with Elastic Structures

13:50 – 14:40

Prof. Dr. Ingenuin Gasser (University Hamburg)

Dynamics Induced by Bottleneck

14:40 -15:10

Coffee break

15:10 -16:00

Dr. K.R. Arun (RWTH Aachen)

A Numerical Method for Shock Propagation Using Three-dimensional Kinematical Conservation Laws

16:00 – 16:50

Prof. Dr. Sebastian Noelle and Dr. Christina Steiner (RWTH Aachen)

Timestep Control for Weakly Instationary Flow

For further information visit

www.mathematik.uni-mainz.de/arbeitsgruppen/numerik

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Abstracts overview:

Prof. Dr. Miloslav Feistauer, DrSc. *Discontinuous Galerkin Method for the Numerical Simulation of Interaction of Compressible Flow with Elastic Structures*

We will be concerned with the simulation of inviscid and viscous compressible flow in time dependent domains. The motion of the boundary of the domain occupied by the fluid is taken into account with the aid of the ALE (Arbitrary Lagrangian-Eulerian) formulation of the Euler and Navier-Stokes equations describing compressible flow. They are discretized by the discontinuous Galerkin finite element method using piecewise polynomial discontinuous approximations. The time discretization is based on a semi-implicit linearized scheme, which leads to the solution of a linear algebraic system on each time level. Moreover, we use a special treatment of boundary conditions and shock capturing, allowing the solution of flow with a wide range of Mach numbers. As a result we get an efficient and robust numerical process allowing the solution of compressible flow with a wide range of Mach numbers. The applicability of the developed method will be demonstrated on several problems.

a) In order to show the robustness of the method with respect to the Mach number, we shall present the results of the computation of flow past an airfoil with very low Mach number.

b) The developed DGFEM is coupled with the numerical solution of a system of ordinary differential equations describing vibrations of an elastically supported airfoil with two degrees of freedom.

c) The second example of fluid-structure interaction is concerned with the coupling of compressible flow in a channel with elastical walls described by the dynamical elasticity equations. This model is used for the simulation of airflow in human vocal folds.

Prof. Dr. Ingenuin Gasser: *Dynamics Induced by Bottleneck*

We explore the dynamics of simple mircoscopic follow- the-leader traffic flow models on a circular road. Using bifurcation techniques we obtain a good picture of the global dynamics. Introducing a bottleneck we need to change the techniques employeed. Nevertheless we explore very interesting dynamics in case of a bottleneck.

Dr. K.R. Arun: *A Numerical Method for Shock Propagation Using Three-dimensional Kinematical Conservation Laws*

The three-dimensional (3-D) kinematical conservation laws (KCL), derived in a ray coordinate system - form an under-determined system of six equations for evolution of a surface in three-dimensional space. In addition, there are three `geometric solenoidal constraints' in ray coordinate-space. For a weak shock, we add two transport equations to 3-D KCL to get a complete system of eight equations of a shock ray theory, which is weakly hyperbolic with incomplete eigenspace. When the constraints are satisfied initially, the Jordan mode of the system disappears. A constrained transport central finite volume scheme for the numerical simulation is developed and we show that our scheme controls the Jordan mode as time progresses. Numerical results substantiate our claim.

Prof. Dr. S. Noelle and Dr. Christina Steiner: *Timestep Control for Weakly Instationary Flow*

We report on adaptive timestep control for weakly instationary problems. The core of the method is a space-time splitting of adjoint error representations for target functionals due to Süli and Hartmann. The main new ingredients are (i) a conservative formulation of the dual problem (ii) the derivation of boundary conditions for a new formulation of the adjoint problem and (iii) the coupling of the adaptive time-stepping with spatial adaptation. For the spatial adaptation, we use a multiscale-based strategy developed by Müller, and we combine his with an implicit time discretization. The combined space-time adaptive method provides an efficient choice of timesteps for implicit computations of weakly instationary flows. The timestep will be very large in regions of stationary flow, and becomes small when a perturbation enters the flow field. The efficiency of the solver is investigated by means of an unsteady inviscid 2D flow over a bump. Part of this work is joint with Siegfried Müller, IGPM, RWTH Aachen.